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TOMATO DISEASES

by

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TOMATO DISEASES

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Introduction

The tomato is grown extensively in Canada; there is hardly a garden that does not have at least a dozen or more plants. Gardeners and farmers in suitable localities grow large acreages for the market and canning factories. In Canada the tomato industry is therefore of special importance.

Tomatoes thrive best on a well-drained and fertile sandy loam, but will also do well on heavier types provided they are well drained. The tomato is a rank feeder, and unless well supplied with plant food, will grow feebly and be more subject to disease. Irrespective then of the physical state of the soil, this crop should be planted in land with high fertility, good drainage, and of high humus content. However, if earliness is essential, a fertile, sandy loam is preferable to the heavier types of soil.

A satisfactory crop of first grade, sound tomatoes can be obtained only from well-nourished plants that are free from disease. To this end, careful attention should be given to the following precautionary and preventive measures.

The Seed

Since certain diseases may be seed borne, seed should be selected from healthy plants only. Tomatoes grown for seed should be carefully inspected and all unthrifty and diseased plants destroyed.

Tomato seed should be disinfected before planting. For this purpose corrosive sublimate, improved ceresan, cuprous oxide, or other recommended seed disinfectants may be used. Corrosive sublimate (mercuric chloride) 1:2000, that is $\frac{1}{2}$ ounce in 6 gallons of water, or 1 tablet to 2 pints of water, is very satisfactory. The seed should be tied in a cheesecloth or muslin bag and submerged in the solution for 10 minutes. It should be agitated with a stick or rod in order that every seed may become covered with the disinfectant. After treatment, the seed should be rinsed two or three times in clean water, and then spread out to dry, or better still, planted immediately.

If dust disinfectants are used, follow the directions printed on the package. A simple way to treat seed with any of these dusts is to put it with the required amount of disinfectant in a jar or bottle, and close it tightly. The jar should not be more than half-filled to permit free shaking in order that every seed may become covered with the disinfectant. Any excess dust may be removed by shaking the seed on a fine sieve. After treatment, the seed may be sown directly or stored in a clean container until required.

The Seedling

The grower must realize that a good many of the diseases affecting tomatoes, such as leaf spot, leaf mould, mosaic, wilts, etc., may start in, and spread from, the seed-bed. This means that special care should be taken to protect the small seedlings from becoming infected. To this end, the disinfected seed should be sown in sterilized soil that is kept free from weeds. The seed should

not be sown too thickly, as crowded seedlings are more subject to "damping-off". Since a continuous damp surface on the seed-bed favours damping-off, it is a good practice to have the soil covered with a thin layer of sand, to ensure more rapid drying of the surface. It is preferable to grow seedlings under glass so that the excess humidity may be more readily driven off by heat and proper ventilation. This is particularly applicable to the seedlings for the fall greenhouse crop, which are so often severly attacked by the leaf mould fungus. Seedlings should not be grown in close proximity to weeds, tomatoes, or potatoes, and should be sprayed at least twice with a fixed copper fungicide, such as cuprocide, basicop, perenox, COCS., copper-A, etc., while still in the seed-bed, or plant-bed, and before being transplanted to the field or greenhouse. Spraying of seedlings is unnecessary in the irrigated districts of British Columbia.

If the above simple measures are faithfully carried out, the grower will start with sound, healthy plants, and under sanitary conditions in the field or greenhouse will have gone a long way in avoiding tomato diseases.

Sanitation

Regardless of the care taken in treating the seed and growing the seedlings, little benefit may be derived if proper sanitary precautions are not taken.

In this connection it a good practice to thoroughly fumigate the greenhouse just *previous to planting therein,* by burning sulphur, at the rate of 1 lb. per 1,000 cu. feet. Better results will be obtained if the sulphur is distributed evenly throughout the house in small piles, rather than in 1 or 2 larger piles.* Such fumigation will not only destroy insects, but will kill many destructive fungi as well. It should be pointed out that fumigation with sulphur is specially recommended for the prevention of the leaf mould disease, but should not be burned in the greenhouse after the tomatoes have been planted.

Since many of the organisms which produce disease in tomatoes remain in the soil for varying lengths of time, it is always advisable to plant the healthy seedlings in sterilized soil, or in soil that has not grown tomatoes, peppers, eggplants, raspberries, or potatoes for some years. This recommendation is based on the fact that certain diseases which attack the crops mentioned above also attack tomatoes.

It is not a good practice to throw the refuse from a tomato crop on the manure or compost pile, because most tomato diseases can survive under these conditions for considerable periods and when such manure or compost is used for tomatoes, they may contract diseases that were on the tomato refuse.

Some tomato diseases may also attack common weeds, and may spread from them to tomato plants. For this reason weeds and unnecessary vegetation should not be allowed to grow in or near the seed-bed or greenhouse.

Since it has been proved repeatedly that workmen who use tobacco may be responsible for infecting tomatoes with mosaic, its use should be avoided while working amongst such plants. As an added precaution, the hands, especially of smokers, should be washed thoroughly with soap and running water before working with tomatoes.

Crop Rotation

The organisms causing certain tomato diseases, such as blights, leaf spots, and wilts, accumulate in the soil, if the same or kindred crops (potato, eggplant, pepper, etc.,) are grown in the same soil year after year. Rotation of crops is, therefore, highly desirable, if not absolutely essential.

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* A satisfactory method of procedure is to kindle small fires in deep metal pans with wood or chips and pour on the sulphur after the blaze has started.

Soil Sterilization by Steam

Where tomatoes have been attacked by soil-borne organisms, the grower must either provide new soil or disinfect or sterilize the old. In obtaining new soil he should be very careful not to use soil that has previously grown the same or related crops. In greenhouses where steam is available, satisfactory sterilization may be effected by any of the following methods.

Pipe Method

Pipes about 3 inches in diameter, with a row of $\frac{1}{4}$-inch holes 6 inches apart, are buried, with the holes facing downward, in parallel rows about 18 inches apart, and 1 foot beneath the surface of the soil. Where several rows of piping are to be used at the same time, the pipes should be connected to a header and steam passed through under pressure.

Inverted Pan Method

In this method, steam is passed into an inverted pan which is forced into the ground, and steam under pressure passed into it. The pan may be of any convenient size, though it is difficult to handle one larger than 70 square feet in area. Before passing in the steam, the pan should be weighted, so as to keep it in the ground and thus prevent the escape of steam around the edges.

Drain Tile Method

This method is in general favour to-day, even though the initial installation is somewhat expensive, because in the long run it is much more convenient and requires less labour to operate. The tiles (3-inch ones are satisfactory) are laid in rows 15 to 20 inches apart, and 12 to 15 inches below the soil surface. Steam is then passed into them through a header. In long greenhouses it will be necessary to divide the tiles into sections, and treat one at a time, in order that the required temperature may be obtained.

With all three methods it is essential to have the soil in a loose, moist condition, for best results. If the soil is too dry, steam will escape too freely, and if too wet, efficient penetration of the soil is not possible. Steam should be in sufficient volume and under sufficient pressure to maintain the soil temperature at a depth of 12 to 15 inches at 180° F. for 1 to 2 hours.

Disinfection with Chemicals

Where steam is not available for soil-sterilization purposes, chemical disinfectants, though less efficient, must be resorted to, and formalin and chloropicrin are commonly used for this purpose.

Formalin

In treating with formalin, the soil should be in a loose, uniformly-moist condition. Formalin should be used in the proportion of 1 gallon to 50 gallons of water, and at the rate of $\frac{1}{2}$ to 1 gallon of the solution to every square foot of soil. After treatment, bags or papers that have been wet with the formalin solution should be placed over the soil for at least 48 hours, in order to retain the formaldehyde fumes in the soil. Thereafter the soil should be turned over and aerated at frequent intervals until the odour of formaldehyde can no longer be detected, when it may be used for planting. This method is particularly adaptable to the small greenhouse and for treating soil in seed-beds, benches, etc.

For small quantities of soil, use formalin at the rate of $2\frac{1}{2}$ tablespoonfuls, diluted with 6 times as much water for each bushel of soil. For larger amounts of soil, use 1 pint to 6 gallons of water, using this solution at the rate of $\frac{1}{2}$ gallon

per cubic foot of soil. In either case, mix the formalin thoroughly with the soil, then cover for at least 2 days with papers or bags, and keep them wet with formalin. Then aerate as above before planting.

Chloropicrin (larvicide)

Whereas formalin is diluted with large quantities of water (1-50), and poured on the surface of the soil, chloropicrin is used at full strength, but in very small amounts, and must be placed several inches below the surface of the soil in holes 10 to 12 inches apart. Therefore, a special injector is used to apply it. This instrument is calibrated to give the correct amount of the chemical at the required depth. After treatment, the top 2 inches of the soil should be kept moist for 3 days by sprinkling it with water. The temperature of the soil should be between 60° F. and 85° F. for best results. Plants should not be planted in treated soil for at least 10 to 14 days, or until all traces of the gas have disappeared. Directions for using chloropicrin accompany all containers.

Disinfection of Plant-bed Frames or Flats

Greenhouse benches, flats, hotbed frames, etc., may be disinfected by drenching with a strong formalin solution made up of 1 gallon of formalin to 25 gallons of water.

Spraying and Dusting

To protect the young seedlings from leaf spots, blights, etc., it is advisable to spray them in the seed-bed or flat. The first application should be made after the true leaves have formed. Two additional applications should be given at 10-day intervals. Fixed coppers, such as cuprocide, perenox, basicop, COCS., copper-A, etc., are preferable to bordeaux. Bordeaux may be used, but it is essential to reduce the usual concentration of hydrated lime, using formalae such as 4-3-40 or 3-2-40, since tomatoes do not tolerate excess lime.

Spraying is essentially a method of prevention, or of checking the further spread of disease, and is not in itself a cure. It is, therefore, always advisable to be on the lookout for the presence of disease in the field, and to spray or dust in plenty of time, especially if leaf spot or blight attacks the crop early in the season, in which case, if unchecked, they may cause considerable defoliation. One or two applications of a fixed copper should be sufficient. If tomato worms are troublesome, lead arsenate at the rate of 2 pounds to each 40 gallons of spray should be added.

It is not necessary to spray field tomatoes in the irrigated districts of British Columbia since the common leaf spots are not found there.

Fungous Diseases

Damping-off

This is primarily a seed-bed trouble, caused by various soil-inhabiting fungi, especially species of *Rhizoctonia* and *Pythium*.

The seedlings may be attacked either before or after they emerge. In the former case the germination is reduced and in the latter, the plants wilt, fall over and die. Occasionally entire beds may be destroyed.

Control

Control measures are based upon the fact that damping-off is caused by soil-borne organisms. Therefore, always use clean soil in the seed-bed. If soil previously used is to be used again, it should be disinfected or sterilized as described under "Sterilization by Steam".

1. Disinfect the seed.

2. Avoid thick seedings, since a crowded seed-bed favours the damping-off fungi.

3. Do not keep the surface of the soil continuously damp, but water plants only when necessary, preferably in the forenoon, so that the surface of the soil will be dry by night.

4. Good ventilation is an absolute necessity.

5. After the seed has been sown, but before the seedlings emerge, copper sulphate, semesan or cuprocide may be applied to the soil as a further protection against damping-off. These chemicals are used as follows: copper sulphate, 1 lb. to 25 gallons of water, at the rate of 1 pint to each square foot of soil; semesan, 1 oz. to $2\frac{1}{2}$ gallons of water, at the rate of 1 quart to each 10 square feet of soil surface, and washed into the soil by sprinkling with water; cuprocide, 1 lb. to 50 gallons water, at the rate of 1 pint per square foot. These latter two chemicals, namely semesan and cuprocide, may even be used after the seedlings have emerged and damping-off begins. However, the earlier the application is made the better. Cheshunt compound may also be used after emergence. This is made up as follows: crush to fine powder 2 parts of copper sulphate and 11 parts of ammonium carbonate. Mix well and store for at least 24 hours in a tightly stoppered glass or stone jar. The solution is prepared by dissolving the mixture in a little hot water and then further diluting with water to make a proportion of $\frac{1}{2}$ oz. of the mixture to 1 gallon of water. Water the plants periodically with this solution.

Collar Rot

At least four different fungi are capable of causing a collar rot, either on seedlings or on more mature plants. However, irrespective of the organism concerned, the disease is manifest by a canker or rot of the stalk at or just above the ground line (Fig. 1). When the stalk becomes girdled, the plant wilts and dies.

The fungi associated with collar rot in Ontario are *Sclerotinia sclerotiorum, Botrytis cinerea, Phytophthora parasitica,* and *Rhizoctonia solani.* In the case of *S. sclerotiorum,* a white mycelial growth, with or without black sclerotia, may be found on the affected tissue, while *B. cinerea* may be identified by a grey mouldy growth.

Control

1. Remove infected plants.

2. Where this disease has occurred, the soil should be sterilized, and the greenhouse fumigated before planting the next crop of tomatoes.

Leaf Spot

Caused by *Septoria Lycopersici* Speg.

Leaf spot causes numerous, small, circular spots on the leaves, stems, petioles, and, in severe cases, even on the fruit (Fig. 2). These spots are generally greyish in colour with a black border, although sometimes continuous black spots are found. In the centre of these spots, small black "pimples", the fruiting bodies of the fungus, may be seen with the aid of a hand lens. The disease starts on the older bottom leaves and, under favourable conditions, progresses upwards. Severely affected leaves turn yellow, dry up, and fall. The damage to the crop is due largely to the reduction of the leaf surface, which in turn reduces the size and quality of the fruit.

In Ontario this disease is present in almost every tomato field; in some localities, however, it is not generally considered of economic importance, since it seldom becomes prevalent until late in the season. At this time, the damage to the crop is of much less importance than when the disease occurs on young plants early in the growing season. In the irrigated districts of British Columbia leaf spot is unknown.

Control

Since the leaf spot fungus lives over winter on dead tomato vines, it is essential that the refuse from a crop be destroyed by burning, or ploughing under. In the greenhouse, all diseased leaves and tops should be carefully gathered and burned.

Not only is it essential to practise strict sanitary measures, but since the leaf spot fungus is capable of living on certain weeds, namely, horse nettle, ground cherry, nightshade, and jimson weed, these weeds should not be tolerated in or near the seed-bed, plant-bed, glass-house, or field where tomatoes are growing. Experience has shown that it is easier to control leaf spot when legumes and cereals are included in the crop rotation, especially if the susceptible weeds are also carefully controlled.

In some seasons it may be necessary to supplement sanitary measures by spraying, particularly if an early infection of leaf spot occurs. One of the fixed coppers already referred to is satisfactory, and one or more applications at 10-day intervals should be sufficient.

Early Blight (Target spot, Black rot)

Caused by *Alternaria solani* (Ell. & Mart.) Jones & Grout.

Early blight, like leaf spot, is responsible for severe defoliation in some seasons. In fact, these two diseases, either separately or in association, are responsible for most of the defoliation that occurs on tomatoes in Canada. In addition to the leaves, early blight also attacks the stems and fruit. On the leaves, circular, dark brown to black spots of varying size are produced. The spots, often up to $\frac{1}{2}$ inch in diameter, are readily recognized by the concentric rings or zonations, hence the name "target spot" (Fig. 3). When these spots occur around the margin of the leaf, their symmetric ring-like appearance is often lost due to the uneven outline of the edge of the leaf. On the stalks, branches, and fruit pedicels, early blight appears as black lesions that subsequently enlarge and elongate and sometimes girdle them. These enlarged lesions on the stalks near the ground are referred to as "collar rot", whereas the lesions on the branches higher up are called "stem cankers".

On the fruit, large, black, leathery, sunken areas are produced. These generally start in some small wound or crack and enlarge in size. Early blight does not occur in the irrigated districts of British Columbia.

Control

Control measures as given under leaf spot apply equally to early blight.

Leaf Mould, Brown Mould

Caused by *Cladosporium fulvum* Cooke.

This is primarily a greenhouse disease, though in some seasons it may attack field tomatoes, or seedlings in the plant-bed.

The symptoms of this disease are yellowish green, indefinite areas on the upper surface of the leaves, accompanied by greenish brown mouldy areas on the under side of the yellow-green areas (Fig. 4). When conditions are favour-

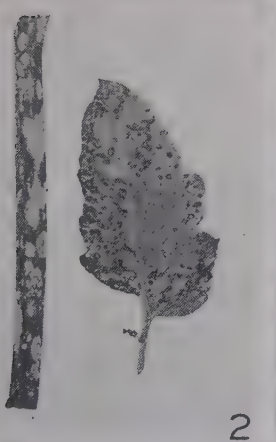
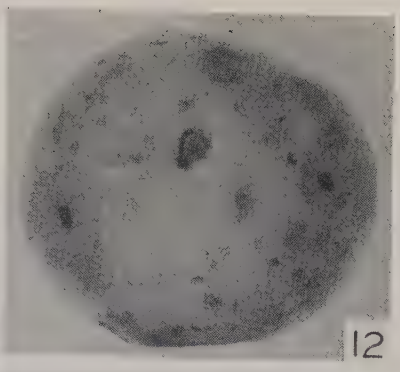
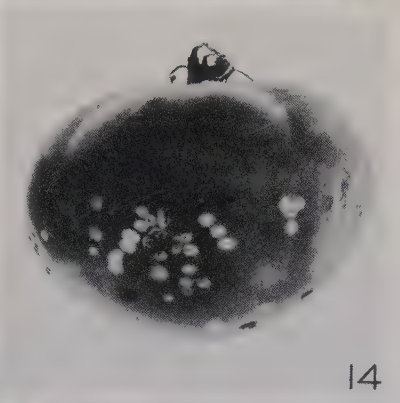
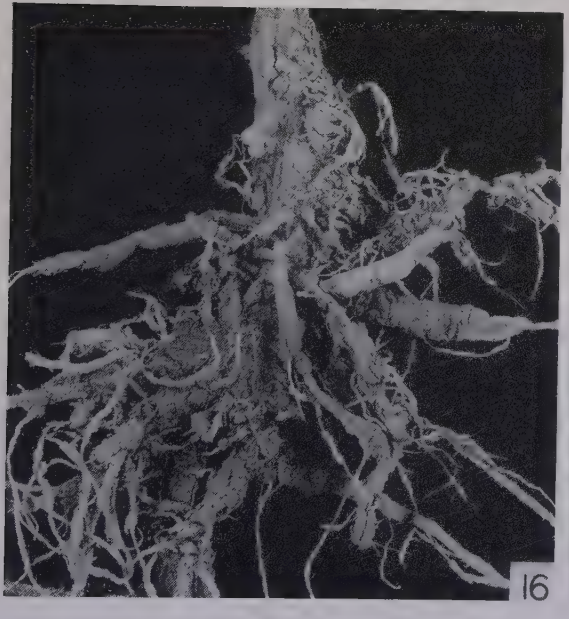


Fig. 1.—Collar rot (left) showing hollow stem, and Botrytis sp. (right) growing on stalk.
Fig. 2.—Leaf spot on stem and leaf.
Fig. 3.—Early blight (greatly enlarged). Note concentric rings in lesions.
Fig. 4.—Leaf mould on underside of leaf.

Fig. 5.—Verticillium wilt; diseased plant on left and healthy plants on right.
Fig. 6.—Late blight on underside of leaf.
Fig. 7.—Buckeye rot. Note concentric rings.
Fig. 8.—Phoma rot. Note the small black fruiting bodies in centre of lesion.
Fig. 9.—Botrytis ring spot.
Fig. 10.—Botrytis watery rot showing the fungus growing on fruit.







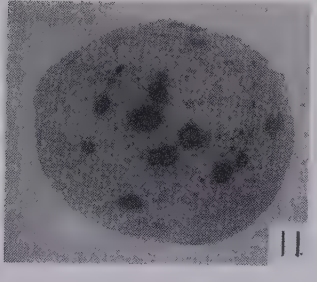


FIG. 11.—Nailhead spot.
FIG. 12.—Anthracnose.
FIG. 13.—Basal rot. Note enlarged cracked lesions on roots.
FIG. 14.—Bacterial canker.
FIG. 15.—Bacterial spot.
FIG. 16.—Nematode galls on roots.

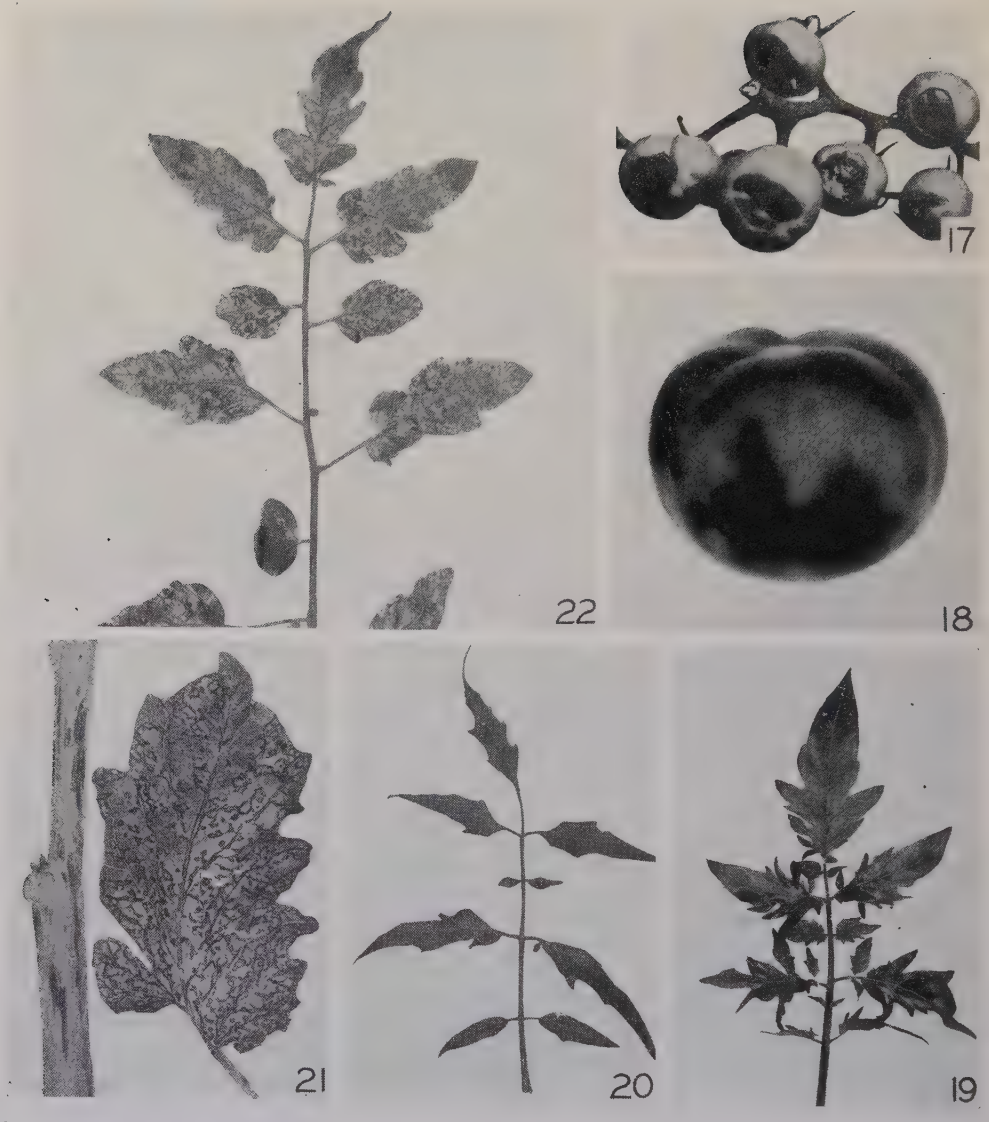


FIG. 17.—Blossom-end rot.
FIG. 18.—Blotchy ripening.
FIG. 19.—Tomato mosaic.
FIG. 20.—Symptoms caused by cucumber mosaic virus.
FIG. 21.—Streak on leaf and stalk.
FIG. 22.—Spotted wilt. Note ring spotting.

able for leaf mould development, the stems, blossoms and fruits, as well as the leaves, may be affected. On the fruit, a black stem-end rot, often involving a considerable portion of the fruit, is sometimes caused by this fungus. Owing to the immense number of spores produced by this fungus, spread takes place very rapidly, especially in the warm humid atmosphere found in greenhouses.

Control

1. The variety Vetomold 121 is highly resistant to leaf mould and is specially recommended for the greenhouse.
2. Keep humidity as low as possible consistent with good growth. This may be done by increasing the temperature and opening the ventilators.
3. Water the plants at the roots, and thus avoid unnecessary wetting of the leaves.
4. All dead diseased plant material should be removed from the greenhouse and destroyed. It is also advisable to pick off the first affected leaves, before the disease has had much of a chance to spread.
5. If leaf mould has been present in a greenhouse, it should be fumigated by burning sulphur at the rate of 1 pound to every 1,000 cubic feet, after the crop has been harvested, and before planting another crop of tomatoes. Fumigation should not be carried out when crops are growing in the greenhouse.

Verticillium Wilt

Caused by *Verticillium albo-atrum* Reinke & Berth.

The fungus responsible for this disease inhabits the soil and gains entrance to tomato plants through the roots. From the roots, it advances through the woody tissue into the stems and leaves, causing the plants to wilt and ultimately die (Fig. 5). Verticillium wilt is favoured by cool, moist conditions.

Verticillium also attacks potatoes, eggplants, and raspberries, hence it is essential to avoid such crops in the rotation.

Control

1. Disinfect seed.
2. In the field, good sanitary measures, such as destruction of diseased tomato vines, along with a 4- to 5-year rotation of crops (avoiding potatoes, eggplants, peppers, etc.) should generally be sufficient to prevent any serious attack.
3. In the greenhouse, sterilization of the soil will satisfactorily control this wilt.
4. A relatively high soil temperature (over 60° F.) will check Verticillium wilt.

Fusarium Wilt

Caused by *Fusarium oxysporium* Schlecht. f. *Lycopersici* (Sacc.) Snyder & Hansen.

This fungus also is soil-borne and gains entrance to the plant through the roots. The fungus grows up through the woody tissue, producing toxic substances which cause the plant to yellow, wilt and die. The woody tissues of the stems of affected plants are stained brown. Fusarium wilt is favoured by high temperatures.

Seedlings, when grown in infested soil, contract the disease, but often do not show it till after they have been transplanted. In this way the disease may be transferred to the field.

Control

1. Use a resistant variety such as Marglobe, Pritchard, Rutgers, Early Baltimore, Break O'Day, etc.
2. Practise a long rotation.

Late Blight

Caused by *Phytophthora infestans* (Mont.) de Bary.

This is primarily a disease of potato, but, under favourable environmental conditions, tomatoes may also become attacked, particularly when they are in close proximity to infected potatoes. Late blight produces on the leaves greenish brown, irregularly shaped, water-soaked spots (Fig. 6). Affected leaves wilt and die and during wet weather usually show a grey mould at the margin of the lesions on the under side of the leaf. Brown cankers are often formed on the stems and the fruit develops a firm, blotchy, greenish brown rot, usually spreading from the stem end. The disease usually spreads rapidly during wet weather, especially if the days are warm and the nights cool. Severe losses may occur during transit and in storage.

Control

1. Crop rotation and sanitation.
2. Keep tomato plantings well separated from potatoes.
3. When the crop is infected, it is advisable to keep tomatoes as long as possible after picking and to regrade them before shipment.

Buckeye Rot

Caused by *Phytophthora parasitica* Dastur.

Although the most common symptom of this disease, and the one from which its name is derived, is on the fruit, it may also produce lesions on the stems and leaves, as well as a damping-off of seedings. Seedlings may be killed either before or shortly after emergence. Stem girdling or collar rot may occur on seedlings or mature plants. Leaf symptoms appear as irregular brown necrotic lesions on the lower leaves. Either green or ripe fruit, especially when in contact with the soil, may become infected through the uninjured skin. A small, greyish brown spot first appears, which enlarges in the form of concentric rings as the rot increases (Fig. 7). The rot, which is leathery in consistency, usually affects the fruit to a considerable depth.

Control

1. Sterilize greenhouse soil.
2. Plant on well-drained soil.
3. The application of a fungicide is beneficial in checking the spread of the disease.

Phoma Rot

Caused by *Phoma destructiva* Plowr.

This disease is rather unimportant in Canada, but as it is found occasionally, a brief description is included here.

The disease affects the fruit in the form of rather large, black, sunken areas in which numerous black "pimples", the fruiting bodies of the causal fungus, are readily seen in the centre of the affected tissue (Fig. 8).

On the leaves, brown to black spots develop, and dark areas may occur on the stems.

Control

Special control measures are not necessary, especially if a crop rotation is followed, the seed is disinfected, and sanitary measures practised.

Botrytis Ring Spot and Watery Rot

Caused by *Botrytis cinerea* Pers.

This disease is found on indoor and field tomatoes when atmospheric humidity is high, and appears on the fruit as a ring spot, with a brownish puncture in the centre. On green fruits, the ring may be pale green or silvery, with the tissue inside the ring generally of a paler green colour. On ripe fruit, the rings are generally yellow. (Fig. 9.)

This same fungus is also capable of producing a soft rot of the leaves, petioles, and fruit (Fig. 10), especially under greenhouse conditions, when the atmosphere is kept too moist. Infection occurs through injuries, cracks on the fruit, etc., and may cause considerable damage.

Control

In the greenhouse, prevent undue humidity. There is no need of preventive measures in the field, since this disease is of uncommon occurrence and rarely causes unmarketable fruit.

Nail Head Spot

Caused by *Alternaria tomato* (Cooke) Weber.

This disease is similar in many respects to early blight, with which it may be confused, but the symptoms on the fruit are diagnostic. Like early blight, it causes leaf spots and defoliation. On the fruit, however, it produces hard, scab-like spots, hence its name. The spots are dark brown and usually small in size, with the discoloration extending beneath the spot into the flesh of the fruit (Fig. 11).

Control

Practise crop rotation and sanitation. In severe cases spray with a fixed copper fungicide.

Anthracnose

Caused by *Colletotrichum phomoides* (Saac.) Chester.

This is primarily a disease of ripe fruit. The early symptoms appear as small, sunken spots, with dark centres, which increase in size, coalesce, and often cover a large area of the fruit, rendering it unfit for market (Fig. 12).

The spores of this fungus are produced in great numbers, and spread infection to sound fruit in containers in transit. Moreover, secondary fungi and bacteria often overrun the anthracnose infection, greatly extending the rot.

Control

1. Destroy all diseased fruits.
2. Destroy refuse from harvested crop.

Basal Rot

Caused by an unidentified fungus.

This disease, though not prevalent, has been observed in greenhouses in Ontario and may cause up to a 50 per cent reduction in crop. Infection is confined to the base of the stalk and root system which is considerably reduced

in size. Most small roots are entirely rotted, while many of the larger ones are either partly or wholly brown, and frequently considerably swollen with the cortical tissues rough and cracked (Fig. 13). This root infection results in leaf chlorosis and defoliation of the plant from the base upwards.

Control

The disease can be controlled by soil sterilization.

Bacterial Diseases

Bacterial Canker

Caused by *Phytomonas michiganensis* (E.F.S.) Bergey *et al.*

This disease is rather uncommon in Canada. However, as it can be most destructive, growers should become acquainted with its symptoms.

The disease may be identified by a one-sided wilting and rolling of the leaves and shoots, and a breakdown of the stem tissue. Light coloured cankers are found on petioles, fruit pedicels, and stems, as well as on the fruit, where the spots are small, tan coloured, with a white margin, the so-called "birds-eye" stage. (Fig. 14.) There is also an internal breakdown in the fruit in the form of discoloured tissue, which may be traced from the stems into the fruit, and even into the seeds.

Control

Since the disease is carried in and on the seed, and is soil-borne, control consists essentially of the use of:—

1. Disease-free seed. Seed may be freed from contamination by fermenting the crushed pulp for 96 hours at a temperature not exceeding 70° F. The fermenting juices should be stirred daily to submerge the pomace that floats to the top.
2. "Clean" seed-beds. Use either fresh "clean" soil, or disinfect the old.
3. A "clean" field. Practise as long a rotation as possible, at least four years.

Bacterial Spot

Caused by *Phytomonas vesicatoria* (Doidge) Bergey et al.

This disease attacks leaves, stems and fruit, though the most conspicuous spots are on the fruit. On the leaves and stems the infections are small, dark spots with a greasy appearance. On the fruit, the spots enlarge to form rough, scabby, dark-coloured lesions, in the centre of which numerous cracks may occur (Fig. 15).

Spread and infection occur during heavy driving rains.

The disease also attacks peppers, producing similar scab lesions on the fruit.

Control

1. Seed from infected plants should never be saved.
2. Disinfect the seed.
3. The treated seed should be sown in sterilized or disinfected soil.
4. Rotate tomatoes with some other crop, avoiding peppers.

Nematodes

Root Knot

Caused by *Heterodera marioni* (Cornu) Goodey.

Root knot is caused by a minute eel-worm or nematode which lives in the soil and attacks the roots of many species of plants, especially tomato, tobacco, and cucumber.

The disease is readily diagnosed by the presence of numerous small swellings or galls on the roots (Fig. 16).

Control

1. Tomatoes should not be grown in soils known to be infected with nematodes.
2. Transplants from an infested seed-bed should be discarded.
3. In the greenhouse, infested soil may be freed from nematodes by sterilization with steam. Chloropicrin has also given satisfactory results in some cases.

Physiological Diseases

Oedema

Oedema is apparent as numerous small swellings on veins, midribs, petioles and stems, which at first are frost white and confined beneath the epidermis but later the epidermis is ruptured and the spots become yellowish brown in colour, and corky in appearance. These wart-like swellings may occur singly or so close together that they form complete ridges, of variously shaped, irregular, raised areas.

This trouble is due to improper greenhouse invironment, such as overheating, overwatering, and lack of ventilation, resulting in the atmosphere above the plants being so moisture-laden that the plants cannot transpire (give off water) sufficiently. In order to avoid, or overcome this trouble, the grower should see that watering and heating are not overdone, and that the atmosphere surrounding the plants is fairly dry.

Blossom-end Rot

Blossom-end rot is associated with environmental conditions and is not caused by any disease-producing organism.

It is confined to the blossom end of the fruit and appears as a dark, sunken, dead area. The rot is dry and firm (Fig. 17) though secondary organisms often invade this tissue and produce a soft rot.

Though the cause of the disease is imperfectly understood, it is usually associated with drought conditions, or irregular water supply. Excessive moisture followed by drought favours the trouble. It often occurs on sandy soils and on freshly manured land. There is some evidence that excess nitrogen favours this trouble. The Marglobe and Pritchard varieties have been shown to be highly resistant in eastern Texas.

In the greenhouse, regularity of water supply should control the disease satisfactorily.

Blotchy Ripening

This condition is encountered mainly under greenhouse conditions, though it has been observed on staked tomatoes in the field. The fruits ripen unevenly, that is, instead of the red coloration developing evenly over the fruit, some areas do not ripen normally, but remain green, giving the fruit a blotchy appearance (Fig. 18). The cause of this trouble is not understood perfectly, but it is apparently connected with potash deficiency and lack of sunshine.

Internal Breakdown

This condition is characterized by breakdown of the internal tissue. The affected areas are small in size and brown to black in colour and of a dry consistency. Though the cause is imperfectly understood, it appears to be associated with excess fertilization, especially excess nitrogen.

Virus Diseases

Tomatoes are subject to at least three mosaic diseases known as green mosaic, yellow or aucuba mosaic, and cucumber mosaic. In addition, potato mottle mosaic may infect tomatoes. Two other virus diseases also attack tomatoes, namely spotted wilt and streak. In British Columbia another virus disease, namely western yellow blight, or tomato yellows, is of considerable importance.

All these diseases are caused by viruses. Though the nature of a virus is as yet imperfectly understood, it is known that it possesses the power to spread rapidly within a plant, with the result that in a short time the sap in all parts of a newly-infected plant contains the virus.

It should be clearly understood that most of these diseases, especially the mosaics, are so contagious that they can be easily spread by workmen who handle or brush against diseased plants and then pass to healthy ones, as in such operations as tying, suckering, cultivating and harvesting, etc. The mosaics, streaks, and spotted wilt are also spread by insects, which in the course of feeding pass from diseased to healthy plants. Western yellow blight is transferred only by leaf hoppers.

It is known that certain tomato viruses may adhere to the clothes, hands, knife, or other implements used during the various cultural operations. However, the hands, knives, etc., can be freed from virus by thoroughly washing them with soap and water.

The virus causing common tomato mosaic may remain alive in the soil for some weeks after the crop has been harvested. At St. Catharines it has been found to be still viable after three months.

It has been demonstrated at St. Catharines Laboratory of Plant Pathology, and elsewhere, that most brands of smoking and chewing tobacco contain the virus of tomato mosaic in a viable state, and that it may adhere to the workmen's fingers and be spread, by contact, to tomato plants during such cultural operations as pruning, tying, etc.

Symptoms

Common or Green tomato mosaic

This disease is widespread, and accordingly is well known to most growers. Its main symptom is a light to dark green mottling of the leaves (Fig. 19). Affected leaves are commonly distorted, puckered, and smaller than normal, while the plant as a whole is reduced in size, pale in colour, and of a spindling growth.

Yellow or Aucuba tomato mosaic

This mosaic is similar in many respects to common tomato mosaic, but differs from it in that the mottling is of a brilliant yellow to yellow-green colour, and the fruit, as well as the foliage, often becomes mottled.

Potato Mottle mosaic

Tomatoes, particularly if grown on soil that has previously produced a potato crop, or if grown in close proximity to potatoes, may become infected with a potato virus which produces a fine, oftentimes indistinct mottle, due to pale yellow areas appearing between the veins. Often small, brown, dead spots accompany this mottling. Tomatoes thus affected do not show pronounced mottling, distortion of leaf tissue, or stunting of plant as a whole.

Cucumber mosaic (Fern-leaf of tomato)

The virus of cucumber mosaic produces on tomato narrow, spindling leaves with excessive indentations, accompanied by mottling. In severe cases this

spindliness is so pronounced that a "shoe string" type of leaf is produced (Fig. 20).

Streak

There are at least two types of streak, one caused by a single virus, and the other the result of infection by a mixture of viruses. Of these, the latter, though less common, is more virulent. Under Ontario conditions mixed-virus streak is generally the result of infection by potato and certain strains of tomato and cucumber mosaics.

The symptoms of streak, whether of the single-virus or of the mixed-virus type, consist of systemic mottling with severe distortion of foliage and stunting of growth, accompanied by pronounced necrotic lesions (dead areas) on leaf, stalk, petiole, or fruit (Fig. 21). In the case of single-virus streak the amount of necrosis may range from negligible to severe, but with mixed-virus streak, necrosis is always present, and is often so severe that affected plants become devitalized to such an extent that little, if any, marketable fruit is produced.

Spotted wilt

This disease, though rather uncommon in Canada, has been reported in several provinces. The outstanding symptom is a bronzing of young leaves, followed by severe stunting and cessation of growth. The bronzing may take the form of isolated spots or may cover most or all of the leaf surface (Fig. 22). The intensity of the bronzing varies from an inconspicuous green-brown glaze to a distinct dark brown to almost black glazed area. Generally, bronzed leaves turn inward and bronzed areas often become necrotic.

Western yellow tomato blight (Tomato yellows)

In some seasons, severe outbreaks of tomato yellows have occured in southern British Columbia. Its severity varies with the season, in bad years the loss running as high as 30 per cent of the crop. The disease is widespread throughout the Pacific coast region of North America, extending from Mexico to southern British Columbia. In some of these districts, the losses sustained have been as high as 90 per cent of the crop, and in many it is the chief limiting factor in the growing of tomatoes.

Diseased plants are readily distinguishable since they are rigid, the leaves are stiff and brittle, and have a marked tendency to roll and droop slightly; no wilting occurs; the veins are generally purplish in colour and the normal green colouring of the leaf gradually gives place to a sulphur yellow coloration. The plant ceases to grow, and fruit already formed likewise ceases to enlarge. Eventually the plant turns brown and dies. The disease runs its course in from one to two weeks. Affected plants sometimes show signs of recovery, but rarely do they become normal again. An examination of the root-system shows the fine rootlets to be brown in colour, and decayed. The outer tissue may be easily rubbed off between the fingers, leaving the central woody cylinder. Careful surveys and field observations, made by the U.S. Bureau of Plant Industry, have shown that conditions which favour a high evaporation rate, likewise favour the development of western yellow blight.

Since this disease is caused by the same virus which causes curly top of beets and is transmitted from beets to tomatoes by leaf-hoppers, these two crops should always be well separated. In Utah, close spacing of plants has reduced percentage of this disease, and increased yields per acre.

Preventive Measures for Virus Diseases

1. Select seed from healthy plants, or use seed 6 months to 1 year old. Newly ripened seed may carry the virus of tomato mosaic.

2. Seedlings should be grown in sterilized soil.

3. The all-too-common practice of starting new seedlings in a section of a house that is at the same time devoted to the growing of a tomato crop, is not to be recommended, unless utmost precautions are taken to avoid spreading the disease from the old plants to the new seedlings. It is preferable to grow the new seedlings in a house where there are no tomatoes.

4. It has been proved that the use of tobacco by workmen while working with tomatoes may be responsible for the infection of the plants with mosaic. Therefore, all users of tobacco should thoroughly wash their hands before working with tomatoes and should avoid the use of tobacco while working with this crop. This is particularly true if the workmen use natural leaf, or "roll their own".

5. All mosaic or streak plants observed in the seed-bed or flats should be destroyed. Plants infected with mosaic or streak should never be transplanted.

6. Rotate tomatoes with some other crop.

7. After the seedlings have been transplanted to their permanent location, they should be frequently inspected for the presence of virus diseases. All affected plants should be rogued and destroyed. Roguing is of value *only* if done early when infected plants are few in number. When doing this, avoid touching the healthy plants.

8. Many different weeds may harbour the mosaic disease, and therefore weeds should not be permitted in or near the plant-bed or greenhouse.

9. In view of the fact that potato and cucumber mosaics pass readily to tomato, it is advisable not to grow these crops in close proximity to tomatoes. The importance of this recommendation is realized when it is pointed out that these viruses, in conjunction with tomato mosaic, produce a severe form of tomato streak. If it is necessary for workmen to work amongst potatoes or cucumbers, as well as tomatoes, the hands should always be thoroughly washed before passing from one crop to the other.

These additional measures apply mainly to greenhouse crops:—

1. It should be a stringent rule in all greenhouses that the hands (also knives and other implements used during the various cultural operations) should always be thoroughly washed immediately after diseased plants have been handled, particularly during the seedling and early transplant stages of the crop.

2. During cultural operations (pruning, tying, etc.), treat all healthy plants first, leaving mosaic or streak plants till the last.

3. In view of the spread by insects, it is advisable to keep the insect population as low as possible. Therefore, frequent fumigation is advisable.

4. The tobacco refuse used for fumigation purposes may be a possible source of infection of the crop, unless it is carefully handled. The ashes and unburned trash should not be mixed with the soil, but should be removed from the house. The hands should be washed after handling the tobacco, and care should be taken to see that none of the tobacco is left lying around on paths, beds, or benches.

5. The practice of using tobacco trash as a fertilizer in tomato beds cannot be recommended, unless it is first sterilized. The use of unsterilized trash may be responsible for wholesale infection of the tomato crop.

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